(28)

PATENT SPECIFICATION

1,195,073

DRAWINGS ATTACHED.

1,195,073

Date of Application (No. 50582/67) and filing Complete Specification: 7 Nov., 1967.

Complete Specification Published: 17 June, 1970.

Index at acceptance:—B5 A(1K2B, 1R58, 2D1A, 2E3, 2J); F2 D(6C7, 6E2); F2 L34.

International Classification:—B 30 b 11/02.

COMPLETE SPECIFICATION.

Powdered Material Briquetting Press.

I, JOHN HALLER, a Citizen of the United States of America, of 18500 Sheldon Road, Northville, Michigan, U.S.A. 48167, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to briquetting presses for compacting powdered materials into desired workpiece shapes before sintering.

Objects of this invention are to provide a screw-operated briquetting press which is more economical, less expensive, more accurate and less noisy than hydraulic briquetting presses and which is not subjected to their leakage.

The invention consists in a powdered material briquetting press, comprising a press frame, a die table disposed intermediate the opposite ends of the press frame, and at least two lower and an upper punch support displaceably mounted on the press frame and adapted to support lower and upper punches, respectively, each punch support being provided with a screw thread which is engaged by an actuating mechanism to effect displacement of the punch support towards and away from the die table independently of displacement movement of any of the other punch supports.

The displaceably mounted supports are preferably of tubular coaxial form and may be operated by electric motors either with limit switch control or magnetic tape control; they may eject the briquette from the die cavity by reverse stripping which employs as much force, if necessary, as the compacting force, in contrast to the comparatively weak stripping force available in hydraulic briquetting presses, and by using selectively-operated magnetic clutches a single motor may be employed for reversibly driving each set of displaceable supports in the lower and upper portions of the press, thereby avoiding the need for an individual reversible electric motor for each support of each set.

Some embodiments of the invention are described below by way of example with reference to the accompanying drawings, in which:

Figure 1 is a front elevation, with the midportion in central vertical section, of a screw-operated briquetting press according to one form of the invention;

Figure 2 is a right-hand side elevation of the press of Figure 1, with the left-hand portion in central vertical section;

Figure 3 is a diagrammatic elevational view of the gearing between the driving motor and the displaceable punch support of the lower actuating mechanism assembly of Figure 1;

Figure 4 is a horizontal section taken along the line 4—4 in Figures 1 and 3;

Figure 5 is a horizontal section taken along the line 5—5 in Figure 3;

Figures 6 to 11 inclusive are enlarged fragmentary views of the central vertical section of Figure 1, showing the successive positions of the moving parts in the successive steps in a cycle of operation of the press;

Figure 12 is an enlarged vertical section taken along the line 12—12 in Figures 13 and 15, of a modified powdered-material compacting assembly for substitution in the midportion of the press of Figure 1, showing an arrangement for briquetting another form of workpiece, with the die cavity filled and ready for the pressing operation;

Figures 13, 14 and 15 are horizontal sections taken along the lines 13—13, 14—14 and 15—15 respectively in Figure 12;

Figures 16 and 17 are fragmentary side elevations, looking in the direction of the

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arrows 16—16 and 17—17 respectively in Figure 12;

Figure 18 is a fragmentary central vertical section similar to the central portion of Figure 12, but showing the relative positions of the punches at the end of the pressing stroke;

Figure 19 is a view similar to Figure 16, but showing the relative positions of the punches at the completion of the ejection of the workpiece; and

Figure 20 is a view looking in the direction of the arrows 20—20 in Figure 17 and in Figure 12.

In general, a screw-operated briquetting press 10 of Figures 1 and 2 consists of a hollow press frame 12 with lower and upper actuating mechanisms 14 and 16 for operating a powdered-material compacting assembly 18 in the approximate mid-portion of the press 10. The press frame 12 includes a hollow base structure 20 and a hollow head structure 22 interconnected by hollow vertical side structures 24 serving both as housings and strain rods. The side structures 24 near their midportions have vertically-spaced inwardly-extending lower and upper shelf-like arms 26 and 28. Mounted on the lower arms 26 are four hydraulic die table cushioning devices 30 (only one of which is shown in Figure 1) with their axes arranged at the corners of a rectangle. Mounted on the side member arms 26 and 28 between each pair of cushioning devices 30 is a vertical guide rod 32.

Reciprocable vertically and extending between the guide rods 32 and cushioning devices 30 is an approximately rectangular die table 34 which rests upon and is operatively connected to the upper ends of piston rods 36, the latter having piston heads (not shown) reciprocable within cylinders 38 of the hydraulic cushioning devices 30 which are provided with hydraulic fluid ports (not shown) connected to a conventional pressure-responsive hydraulic cushioning circuit adapted to permit the piston rods 36 and die table 34 to yield downward from a starting level 35 in response to that attainment of a predetermined pressure within the cylinders 38 of the hydraulic cushioning devices 30 and to return the die table 34 to its upper portion of Figure 1 at the end of each operating cycle. Extending downwardly from the upper arms 28 of the frame side structures 24 into engagement with the top of the die table 34 are four stop rods 40 coaxial with the piston rods 36. The die table 34 is bored vertically for the passage of the guide rods 32 and centrally for the reception of a compacting die 42, shown more fully in Figures 6 to 11 inclusive.

The die 42 is provided with a central die bore 44 extending downward therethrough from its upper surface 46 (Figures 6 to 11) and containing a flanged tubular lower outer punch 48 within which is reciprocably mounted a flanged tubular lower intermediate punch 50. Reciprocably mounted within the intermediate punch 50 is a flanged tubular lower inner punch 52. Reciprocably mounted within the inner punch 52 is a central core rod 54. The lower punches 48, 50 and 52 and core rod 54 are movable independently of one another by mechanism described below. The outer lower tubular punch 48 is seated and secured at its flanged lower end in a correspondingly recessed rectangular lower platen 56 which is disposed below the die table 34 and extends laterally past the guide rods 32 and piston rods 36 and is bored and cut away respectively for passage thereof (Figure 1).

An approximately rectangular upper platen 58 disposed above the die table 34 is bored and cut away respectively for the passage of the guide rods 32 and stop rods 40 in a manner similar to the lower platen 56. Thus, the guide rods 32 also prevent rotation of the die table 34 and of the upper and lower platens 58 and 56. The upper platen 58, similarly to the lower platen 56, is recessed for the reception of a flanged upper outer tubular punch 60 secured therein at its flanged upper end (Figures 6 to 11). Reciprocably mounted within the outer tubular punch 60 is a flanged upper tubular inner punch 62 which is bored to snugly but slidably receive the core rod 54.

The above-described die and the upper and lower punches are operated in the manner shown in Figures 6 to 11 to produce a briquette or compact constituting a complex workpiece W. The workpiece W is shown, for purposes of illustration, as including, for example, upper and lower tubular hubs U and L and, between these, annular stepped outer and inner flanged portions O and I integral therewith. The workpiece W is formed by the press 10 from powdered material P (Figure 6), such as powdered metal known to those skilled in the powder metallurgy art.

For the purpose of filling with powdered material P a die cavity 64 formed by the die bore 44 and the various punches and the core rod, there is provided a hollow bottomless reciprocable filling shoe or hopper 66 (Figures 2 and 6) which is movable back and forth across the mouth of the die bore 44 upon the upper die surface 46 by an L-shaped arm 68 reciprocable in a slotted bracket 70 secured and extending rearwardly from the rearward end of the die table 34 and screw-threaded at its lower end to threadedly engage a screw shaft 72 journalled at its opposite ends in the bracket 70 and coupled to the rotary shaft of a reversible electric motor 74. The electric motor 74 is connected in a suitable electric

circuit (not shown) to operate in timed relationship with the other elements of the press 10 so as to advance the filling shoe 66 over the die bore 44 to permit the die cavity 64 to be filled at the beginning of the cycle of operation shown in Figure 6, and thereafter to retract the filling shoe immediately to its rearward position of Figure 2, the upper platen 58 being cut away for clearance of the filling shoe 66 upon its downward stroke.

Each of the above-described punches 48, 50, 52, 60 and 62 is moved upward or downward by its own individual tubular punch support which in turn is held against rotation while moved upward or downward by a rotary gear nut threaded upon it which is driven by the lower or upper actuating mechanisms 14 and 16 by way of selectively-operated magnetic clutches. In particular, the lower platen 56 carrying the tubular lower outer punch 48 (Figures 6, 7, 9 and 11), the intermediate punch 50 and the inner punch 52 are coupled respectively to lower outer, intermediate and inner tubular punch supports 76, 78 and 80 which telescope with one another and are screw-threaded along their lower end portions as well as being keyed, splined or otherwise held against rotation. Threaded upon the screw-threaded lower end portions of the punch supports 76, 78 and 80 respectively (Figure 2) are rotary gear nuts 82, 84 and 86 resting upon roller thrust bearings 88, 90 and 92, which in turn are supported by the frame 12. The gear nuts 82, 84 and 86 are so designated for conciseness because they are internally screw-threaded to threadedly engage their respective punch supports 76, 78 and 80 and at their upper ends are provided with annular toothed worm wheel portions 94, 96 and 98 respectively, by which they are rotated by means of the lower actuating mechanism 14.

Similarly, the upper platen 58 carrying the upper outer punch 60 and the upper inner punch 62 are coupled respectively to upper outer and inner tubular punch supports 100 and 102 which telescope with one another and are screw-threaded along their upper end portions as well as being keyed, splined or otherwise held against rotation. Threaded upon the screw-threaded upper end portions of the punch supports 100 and 102 respectively are gear nuts 104 and 106 bearing against roller thrust bearings 108 and 110, which in turn are supported by the frame 12. The gear nuts 104 and 106 are also internally screw-threaded to engage their respective punch supports 100 and 102, and at their lower ends are provided with annular toothed worm wheel portions 112 and 114 by which they are rotated by means of the upper actuating mechanism 16. For reasons of clarity the punches are shown unitary with their punch supports in Figures 1 and 2, but are in fact coupled thereto and supported thereby in a known manner.

The lower actuating mechanism 14 is shown diagrammatically in Figure 3 and in detail in Figures 4 and 5, and is driven by a variable speed motor 116 mounted in a housing 118 bolted or otherwise secured to the frame 12. The rotary motor shaft 120 is coupled as at 122 to the hub 124 of a driving gear 126 (Figure 4) with which meshes a driven gear 128, the hub of which is loosely and rotatably mounted upon a middle output shaft 130. Keyed or otherwise drivingly secured to the outer end of a worm shaft 132 coaxial with the output shaft 130 is a cone drive worm or pinion 134 which in turn meshes with the annular worm wheel portion 96 of the gear nut 84 (Figure 2).

The hub of the gear 128 is keyed or otherwise drivingly secured to the driving element 136 of an automatically-braking magnetic clutch 138, the driven clutch element 140 and the rotary magnetic brake element 142 of which are keyed to a tubular shaft 144 which in turn is keyed to the output shaft 130 and also to the worm shaft 132 (Figure 4). The rotary brake element 142 is engaged by a stationary brake element 146 fixedly mounted on the adjacent press frame side structure 24. As is well known to electrical engineers, the braking magnetic clutch 138 is so connected in the electric circuit that when the magnetic clutch 136, 140 is energized, the magnetic brake 142, 146 is de-energized and vice versa, for the purpose of preventing overrunning of the output shaft 130 and worm shaft 132.

The driven gear 128 (Figures 3 and 5) meshes with the forward ring gear 148 of each of a pair of double ring gear idlers 150 (Figure 5) located above and below the driven gear 128. The forward ring gears 148 of the idlers 150 in turn mesh directly with gears 152 and 154 respectively (Figure 3) selectively drivingly connected to upper and lower output shafts 156 and 158 through automatically-braking magnetic clutches (not shown) similar to the braking magnetic clutch 138 of Figure 4. The upper and lower output shafts 156 and 158, like the middle output shaft 130, are connected to worm shafts 160 and 162 respectively carrying worms (not shown) similar to the worm 134 and similarly meshing with the worm wheel portion 94 or 98 of the gear nut 82 or 86 on the punch support 76 or 80 respectively. The gearing just described actuates the three punch supports 76, 78 and 80 and their connected tubular punches 48, 50 and 52 respectively in an upward or forward pressing stroke.

Returning to the double ring gear idlers 150 (Figures 3 to 5), meshing with the rear-

ward ring gear portion 164 is a central idler 166 and also upper and lower idlers 168 and 170 respectively. The idlers 166, 168 and 170 in turn mesh with middle, upper and lower pinions 172, 174 and 176 respectively loosely and rotatably mounted upon their respective upper, middle and lower output shafts 156, 130 and 158. The hub of the pinion 172 is keyed to the driving clutch element 175 of a magnetic clutch 177, the driven element 178 of which is keyed or otherwise drivingly connected to the middle output shaft 130. The electric control circuit is so arranged that when the magnetic clutch 177 is energized, the magnetic clutch 136, 140, of the magnetic braking clutch 138 is de-energized, and the motor 116 then moves the punch support 78 downward rapidly upon its retraction or return stroke.

In a similar manner, the hubs of the upper and lower pinions are selectively drivingly connected through magnetic clutches (not shown) similar to the magnetic clutch 177, to their respective output shafts 156 and 158 (Figure 3), for rapid retraction of their respective punch supports 76 and 80 (Figure 2). Since the reversible clutching assembly including the power transmission gearing and clutches mounted on and adjacent the shaft 130 is substantially repeated in the upper actuating mechanism 16, it is conveniently generally designated by the reference numeral 180 and includes the gear 128, shafts 130 and 132, worm 134, magnetic clutch and brake assembly 138, double ring gear idler 150, gears 166 and 172 and magnetic clutch 177. It will be observed from Figure 4 that the various gears and shafts described above have been mounted in conventional anti-friction bearings for smooth and efficient operation, and this also applies to the additional gears shown diagrammatically in Figure 3. It is believed that these bearings require no detailed description since they are conventional and do not form a part of the invention.

The core rod 54 (Figures 6 and 11) is actuated independently of the lower and upper actuating mechanisms 14 and 16 in that it has a jointed connection 182 at its lower end (Figure 2) with a screw shaft or core support 184 passing through a housing 186 secured to the bottom of the bed structure 20 and keyed, splined or otherwise held against rotation. Threadedly engaging the screw shaft or core support 184 is a gear nut 188 consisting of a worm wheel with its hub internally screw-threaded to mate with the core support 184 and engaged by a worm (not shown) mounted on the drive shaft of a reversible electric motor 190 (Figure 1). The motor 190 is so connected in the electrical control circuit that it is movable in a forward or reverse direction during the operation of the general circuit to rotate the gear nut 188 in a forward or reverse direction and consequently to move the core support 184 and core rod 54 upward or downward as shown in Figures 6 to 11.

The upper actuating mechanism 16 mounted in the hollow head structure 22 is generally similar to the lower actuating mechanism 14 but is simpler because it actuates only the two punch supports 100 and 102. Power is obtained from an electric motor 192 (Figure 2) which rotates constantly in one direction like the lower driving motor 116 to rotate a double-ring gear 194 (Figure 1) similar to the double ring gear idlers 150 with one of its ring gears directly driving upper and lower gears 196 and 198 respectively of upper and lower reversible clutching assemblies 200 and 202, generally similar to the reversible clutching assembly 180 shown in the central portion of Figure 4 and similarly employing worm driving shafts 204 and 206 which in turn drive the gear nuts 106 and 104 (Figure 2) on the inner and outer upper punch supports 102 and 100. The second ring gear of the double ring gear 194 drives upper and lower idlers 208 and 210 which in turn reversely drive upper and lower reversing gears 212 and 214 loosely and rotatably mounted on the upper and lower shafts 204 and 206. Magnetic clutching brakes and clutches similar to the magnetic clutching braking assembly 138 and magnetic clutch 176 of Figure 4 selectively drivingly connect either the forward drive gears 196 and 198 or the reverse gears 212 and 214 to their respective shafts 204 and 206 in a manner similar to that described above in connection with Figures 3, 4 and 5. Clutching in the forward driving gears 200 and 202 causes the gear nuts 106 and 104 to drive the upper inner and outer punch supports 102 and 100 downward in the manner shown in Figures 6 to 11, whereas clutching in the reversing gears 212 and 214 rapidly retracts the punch supports 102 and 100.

The operation of the individual mechanical elements and subassemblies has been described above in connection with their construction. In the operation of the screw-actuated briquetting press 10 as a whole (Figures 1 to 11), let it be assumed that the moving parts are in their retracted or starting positions shsown in Figure 2 and that the filling shoe or hopper 66 has been filled with suitable powdered material P, also that the lower punches 48, 50 and 52 and core rod 54 have been moved to their positions shown in Figure 6, and that the upper punches 60 and 62 have been moved into their relative positions shown in Figure 7, but retracted as shown in Figure 6. During the first step of operation, the motor 74 (Figure 2) is actuated to rotate the screw shaft 72 in a forward direction and propel

the filling shoe 66 over the die cavity 64 (Figure 6), whereupon the powdered material P falls into the die cavity 64. The control circuit then reverses the motor 74 to retract the filling shoe 66 to its rearward position shown in Figure 2.

The upper actuating mechanism 16 is now operated (Figure 7) to move the upper punches 60 and 62 downward into the die cavity 64 while the core rod 54 is moved upward above the top surface 46 of the die 42, where it telescopes with the inner upper punch 62. This action partially compresses the powdered material in the die cavity 64 and causes it to fill all portions thereof as well as to rise around the core rod 54 into the space between the upper outer and inner punches 60 and 62. The die table 34 thus far remains with the upper surface 46 of the die 42 coincident with the starting level 35.

The upper outer and inner punches 60 and 62 now move downward (Figure 8) in the same axially-spaced relationship to compress the outer flange O (Figure 11), at the same time forcing the die table 34 and the upper surface 46 of the die 42 to move downward from the starting level 35 as the cushioning devices 30 operate to yield in response to the attainment of a predetermined pressure. The upper outer punch 60 now maintains its position (Figure 9) while the upper inner punch 62 is moved downward and the lower inner punch 52 is moved upwards to form the upper and lower hubs U and L. This descent of the die table 34 and die 42 while the lower outer and intermediate punches 48 and 50 remain stationary also causes compacting of the inner flange portion I. The workpiece W, which in this instance is a compacted unsintered briquette, has now been fully compacted and is ready to be ejected.

Ejection (Figures 10 and 11) is accomplished in two stages by reverse stripping, in order to prevent damage to the outer and inner flange portions O and I relatively to the upper and lower hubs U and L, since the briquette W is relatively fragile before sintering. The upper platen 58 and upper outer and inner punches 60 and 62 are moved upward to their retracted positions (Figure 10), while at the same time the cushioning devices 30 are operated to move the die 42 still further downward below the starting level 35 while the lower outer, intermediate and inner punches 48, 50 and 52 and core rod 54 remain stationary. This action withdraws the die 42 downward so that its bore 44 slides past the rim of the workpiece W, leaving the outer flange O exposed. Finally (Figure 11), the lower outer and intermediate punches 48 and 50 and core rod 54 are moved downward simultaneously while lower inner punch 52 is moved upward to the level of the surface 46 of the die 42, ejecting the workpiece W. The latter is then removed, and the cushioning devices 30 operated to return the die table 34 and die 42 upward into the starting position with the upper die surface 46 coinciding with the starting level 35. The lower intermediate and inner punches 50 and 52 and core rod 54 are then moved downward from their positions shown in Figure 11 to positions below the level of the top of the lower outer punch 48 constituting their starting positions shown in Figure 6 and the press 10 is ready to execute another cycle of operation.

The screw-operated briquetting press 10 of Figures 1 and 2 is further so arranged that the forward and rearward halves (Figures 1, 2 and 4) of subassemblies of the lower and upper actuating mechanisms 14 and 16 may be slid forwardly and rearwardly respectively as "package units" for repair or maintenance purposes, without the necessity of disturbing the press frame 12 and without removing either the base structure 20 or head structure 22 from the side structures 24. Disconnection occurs at the keyed connection (Figure 4) between the tubular shaft 144 and worm shaft 132. For this purpose, the forward and rearward halves of the upper and lower mechanisms 16 and 14 are mounted on slideways 220 and 222—224 respectively and slide adjacent the press head 22 at its lower surface 226 and the press bed 20 at its upper surface 228, respectively. The slideways 220 and 222—224 are formed in the inner faces of the hollow vertical side structures 24. These forward and rearward subassemblies of each mechanism 16 or 14 when thus removed may be worked upon separately and the previously-necessary time-consuming complete disassembly of the frames of prior presses by disconnecting their heads and beds from their strain rods is completely avoided in the present press 10. In this manner, the "down time" of the press 10 is minimized during repair or replacement.

Furthermore, the powdered material compacting assembly 18, known as the "tooling" in the press industry, may be similarly removed without disturbing the press frame 12 and without disconnecting the head 22 or bed 20 from the vertical side structures 24. The detailed construction of the disconnecting arrangement for the guide rods 32 from the lower and upper shelf-like arms 26 and 28 is the same as shown at the four corners of Figure 12, upon a larger scale than was possible in Figure 1. The remainder of Figure 12, however, is for a modified powdered material compacting assembly, generally designated 230.

To facilitate unit removal of the powdered material compacting assembly 18 or 230, the lower and upper shelf-like arms 26 and 28

are machined flat and horizontal at 231 and 232 respectively and provided in the middle thereof with rearwardly-extending lower and upper horizontal grooves or keyways 234 and 236 respectively (Figure 12). Mounted in abutting relationship to the flat horizontal surfaces 231 and 232 on the lower and upper arms 26 and 28 are elongated lower and upper rectangular blocks 238 and 240 respectively, these being drilled vertically to receive the reduced diameter screw-threaded lower and upper end portions of guide rods 242 and stationary piston rods 244 (Figures 12 and 13) carrying screw-threaded retaining nuts 246. There are four guide rods 242 similar to the guide rods 32 of Figure 1 and arranged in a rectangular formation and two stationary piston rods 244 mounted between them. Mounted in each keyway 234 or 236 (Figure 12) is an elongated bar key 248 which in turn is bored to provide clearance for rotation of the nuts 246 (Figures 17 and 20).

In order to clamp the powdered-material compacting assembly 18 tightly in position, the upper blocks 240 are provided with inclined upper surfaces 250 slanting downwardly from the midportion thereof (Figure 16). Each block 240 is also bored and screw-threaded at each of its opposite ends to receive two pairs of adjusting screws 252, each pair of which also passes through the smoothly-drilled downward arms 254 of two pairs of oppositely-tapered L-shaped gibs or wedges 256 having upwardly and inwardly-tapered lower surfaces 258 with flat horizontal upper surfaces 266 slidably engaging the flat lower surfaces 232 on the shelf-like upper arms 28 (Figure 12). As a consequence, assuming right-hand screw-threads, when the screws 252 are rotated clockwise (Figure 12), the wedges or gibs 256 are moved inward (Figure 16), the co-action between the inclined surfaces 250 of the block 240 and the inclined surfaces 258 of the gibs or wedges 246 taking up clearance in a vertical direction and tightly clamping the rods 242 and 244 of the material compacting assembly 18 between the lower and upper shelf-like arms 26 and 28. The lower blocks 238 and bar keys 248 (Figures 12 and 14) lack the wedging arrangement 250, 256 just described but are otherwise of similar construction.

The modified compacting assembly 230 is provided with an approximately rectangular die table 260 with a top surface 261 and lower and upper platens 262 and 264 respectively mounted above and below it (Figure 12) in sliding engagement with the four guide rods 242. Each is taper-bored around the guide rods 242 to receive tapered bearing bushings 266, each split longitudinally and threaded at its opposite ends to receive correspondingly-threaded opposite adjusting nuts 268 and 270. By tightening one of the nuts 268 and loosening the other nut 270 or vice versa, each tapered bearing bushing 266 may be moved upward or downward in its respective tapered bore so as to increase or reduce the clearance between it and its respective guide rod 242.

As in the compacting assembly 18 of the press 10 of Figure 1, the upper platen 264 is bored centrally to receive and be secured to the flanged lower end of the upper outer tubular punch support 100 within which, as before, is telescopingly mounted the upper inner tubular punch support 102, to the lower end of which is secured the upper punch 272 (Figure 12). The modified compacting assembly is shown as employing only one punch 272, because of the particular configuration of the workpiece, instead of the two upper punches 60 and 62 of the assembly 18 of Figures 1, 2 and 6 to 11 inclusive.

The upper platen 264 (Figure 14) is provided with bores 274 disposed with their centers in the central transverse plane thereof. Bolted to the upper platen 264 above each of the bores 274 is a stop cap 276 (Figure 12) which is bored centrally for the passage of its piston rod 244 and on its lower surface is provided with a cup-shaped stepped recess 278 provided with an annular stop shoulder 280. Slidably received within each bore 274 as the upper platen 264 descends is an internally screw-threaded stop sleeve 282 having an upper stop shoulder 284 engageable with the stop shoulder 280 to cause the upper platen 264 to then transfer its motion to the die table 260 in the manner described below.

The stop sleeve 282 at its lower end is threaded onto the upstanding externally screw-threaded tubular upward extension 286 of the upper cylinder head 288 which is also bored centrally for the passage of the piston rod 244. The extension 286 is counterbored to receive a conventional packing 290 for preventing leakage of hydraulic fluid around the piston rod 244. The packing 290 is compressed between a flanged lower bushing 292 and an upper annular retainer 294 bolted to the upper end of the extension 286 and screw-threaded externally in continuation thereof for threadedly engaging the internally screw-threaded stop sleeve 282. An annular flexible flanged wiping ring 296 encircling the stop sleeve 282 excludes dirt. The stop sleeve 282 is provided with peripheral notches or flats (not shown) to receive a spanner or other wrench by which it may be rotated to move it upward or downward relatively to the portions 286 and 294 in order to vary the point at which the upper platen 264 will positively engage the die table 260 through the intermediate

agency of the stop sleeve 282 and cylinder head 288 at each end thereof.

The die table 260 at each end and centred in its central vertical plane is provided with a bore 298 (Figure 12) containing a cylinder sleeve 300 of wear-resisting material, such as hardened steel which is also highly honed or polished, and this is held in position between each upper cylinder head 288 and a corresponding lower cylinder head 302, both bolted to the die table 260. The upper and lower cylinder heads 288 and 302 are counterbored at the inner ends of angled fluid passageways 304 and 306 respectively which connect with upper and lower fluid passageways 310 and 308 extending obliquely rearward through the die table 260 (Figures 12 and 13). These terminate in a port 312 connected by suitable high pressure hydraulic flexible hose to a hydraulic pressure fluid circuit, such as hydraulic oil under pressure. This circuit contains a spring-centred four-way valve (not shown) by means of which fluid can be admitted through one of the passageways 304, 310 and discharged at a predetermined pressure from the other fluid passageway 306, 308 and vice versa, as explained below in connection with the operation of the invention.

The cylinder sleeve 300 during its ascent or descent along with the die table 260 is engaged by a compound piston head 314 (Figure 12) mounted at the midportion of the piston rod 244, which actually consists of headed halves with their heads or flanges 316 abutting one another and clamped together by the same bolts (not shown) which clamp together the three annular portions of the compound piston head 314 and its annular seals. The lower cylinder head 302, like the upper cylinder head 288, is similarly provided with a flanged bushing 318 and packing 320 in its downward tubular extension 322.

Bolted to the lower end of the extension 322 is a four-lobed stationary stop sleeve 324 having four outwardly-projecting arcuate stop lobes 326 (Figure 15). Depending upon the position of a rotary external stop sleeve 330, the external stop lobes 326 register with or clear four corresponding inwardly-projecting arcuate stop lobes 328 mounted inside the rotary external stop sleeve 330 (Figure 12). Figure 15 at its right-hand side shows the lobes superimposed so as to be in registry whereas its left-hand side shows the lobes out of registry so as to clear one another. From Figure 15 it will be seen that the stop lobes 326 and 328 are each spaced circumferentially to occupy one-eighth of the circumference of their respective portions 324 and 330 so that a rotation of forty-five degrees of the external stop sleeve 330 in one direction or the other moves the inwardly-projecting stop lobes 328 into or out of registry with the outwardly-projecting stop lobes 326. In this manner, the die table 260 can be selectively permitted to "float" upward or downward when the stop lobes 326 and 328 are out of registry or brought to a positive halt by them when they are in registry. The lower platen 262 is provided at its opposite ends (Figure 15) with inwardly-cutaway portions 331 to afford clearance for passing the stop sleeves 324 and 330.

Bolted or otherwise secured to the lower end of the stop sleeve 330 is a rotary cylindrical block 332 which is held down against the elongated rectangular block 238 by a flanged retaining ring 334 bolted thereto. The rotary block 332 is provided with external notches or flats for the engagement of a wrench or spanner, or is optionally provided with a handle (not shown) for rotating it and the stop sleeve 330 connected to it.

The die table 260, like the die table 18, is centrally bored and counterbored to receive a flanged cylindrical compacting die 336 with a top surface 337 and which in the present instance is bored and counterbored to receive a hollow cylindrical die liner 338, the bore 340 of which constitutes the die cavity. The die 336 and liner 338 are recessed to receive a retaining ring 342 which holds them together. As in the compacting press 10, the bottom of the die cavity 340 is constituted by the upper ends of three telescoping tubular punches, namely lower outer, intermediate and inner tubular punches 344, 346 and 348 respectively, with a core rod 350 within the inner punch 348. The lower tubular punches 344, 346 and 348, as before, are connected respectively to and reciprocated by the lower outer, intermediate and inner telescoping screw plungers 76, 78 and 80 in the manner described above. Similarly, the core rod 350 is provided with a screw connection 182 to the core-rod-operating screw shaft or core support 184 in the manner also described above in connection with Figures 1 and 2.

The particular workpiece W1 (Figure 19) shown for purposes of exemplification as produced by the modified powdered material compacting assembly 230 has a hollow cylindrical body portion B. This contains an annular bottom groove G which divides its lower portion into outer and inner axially-extending annular flanges F1 and F2, the outer and inner surfaces of which are determined by the die bore 340 and core rod 350 respectively.

The operation of the modified compacting material assembly 230, when placed in the briquetting press 10 of Figures 1 and 2 in place of the powdered material compacting assembly 18, follows a similar action, with certain differences determined by the nature of the modified workpiece W1. The

top of the core rod 350 is initially positioned level with the top of the die table 260 by suitably operating the motor 190 (Figure 1) to rotate the gear nut 186 and move the core rod operating screw shaft 184 upward. The outer stop sleeves 330 are rotated into non-registering or clearing positions as shown at the left-hand side of Figure 15. The internally screw-threaded stop sleeves 282 are also moved upward by rotating them relatively to the tubular extensions 286 of the upper cylinder heads 288 to position their upper ends 284 at the desired halting position for the upper platen 264. As in the operation of the compacting assembly 18, as shown in Figures 6 to 11 inclusive, the lower outer, intermediate and inner tubular punches 344, 346 and 348 are retracted to their maximum depths by operating the lower outer, intermediate and inner punch supports 76, 78 and 80 respectively, and the upper punch 272 retracted to its maximum height by operating the upper outer and inner tubular punch supports 100 and 102.

During the first or filling step of operation, the motor 74 (Figure 2) is actuated, as described above, to move the filling shoe 66 over the die cavity 340 (Figure 12) as it did over the die cavity 64 in Figure 6, whereupon the powdered material P, as before, falls into the die cavity 340. The control circuit, operated in a suitable way as by a tape, then reverses the motor 74 to retract the filling shoe 66 to its rearward position shown in Figure 2, leaving the die cavity 340 filled loosely but accurately with powdered material P. The die table 260 thus far remains with its upper surface 261 and the upper surface 337 of the die 336 coincident with the starting level 35.

The upper actuating mechanism assembly 16 is now operated to move the upper punch 272 downward into the die cavity 340 while the core rod 350 is moved upward above the top surface 337 of the die 336 (Figure 18) where it telescopes with the upper punch 272. This action partially compresses the powdered material P in the die cavity 340 and causes it to fill all portions thereof, including the recesses formed between the intermediate punch 346 and the die liner 338 and core rod 350 respectively (Figure 12). The lower outer, intermediate and inner punch supports 76, 78 and 80 (Figure 12) are now operated to move the lower outer, intermediate and inner tubular punches 344, 346 and 348 upward (Figure 18) while the upper punch 272 is caused to move further downward (Figure 18), further compressing the powdered material in the die cavity 340. Meanwhile, the hydraulic fluid within the cushioning cylinders 300 at their upper ends is permitted to escape at a controlled predetermined pressure through the lower passageways 304 and 310 while hydraulic fluid is admitted to the passageways 306 and 308 to fill the space at the lower ends of the cylinders 300, permitting the cylinders 300 to yieldingly move downward past the stationary piston heads 314, carrying with them the die table 260. While this occurs, the outwardly-projecting lobes 326 of the inner stop sleeve 324 move downward past the spaces between the inwardly-projecting lobes 328 of the outer stop sleeve 330, which, as previously stated, are in the non-registering open positions shown at the left-hand side of Figure 15.

Under these conditions, the upper platen 264 and die table 260 continue to move downward until the internal annular shoulders 280 within the caps 276 engage the upper ends 284 of the screw stop sleeves 282, positively transferring to the die table 260 the descending motion of the upper platen 264 together with the upper punch 272. The various punches 272, 344, 346, 348 and core rod 250 now occupy the relative positions shown in Figure 18, with compacting accomplished.

Ejection of the compacted workpiece W1 is now accomplished by direct stripping, in contradistinction to the reverse stripping carried out in the description of the operation of the compacting assembly 18 of Figures 1 and 6 to 11 inclusive. To do this, the upper outer and inner punch supports 100 and 102 are operated to retract the upper punch 272 and upper platen 264 to their uppermost positions shown in Figure 12. The core rod 350 is also retracted downward until its top is level with the top surface 337 of the die 336, by reversely operating the motor 190 (Figure 1) to move the core rod screw shaft 184 downward (Figure 19).

The lower outer, intermediate and inner tubular punches 344, 346 and 348 are now moved upward until the upper ends of the punches 344 and 348 are level with the upper surface 337 of the die 336 while the top of the lower intermediate punch 346 moves above the level 337, thereby directly ejecting the workpiece W1 from the die cavity 340 (Figure 19). The workpiece W1 is then removed, and the hydraulic pressure fluid admitted through the passageways 304 and 310 to the upper ends of the cylinders 300 while permitting discharge of hydraulic fluid through the passageways 306 and 308 at the lower end thereof, thereby causing the cylinders 300 to rise, carrying with them the die table 260 while the piston heads 314 and piston rods 244 remain stationary until the top surfaces 261 and 337 of the die table 260 and die 336 return to coincidence with the starting level 35. The lower outer, intermediate and inner punches 344, 346 and 348 and core rod 350 are then moved downward to the extent necessary to again form

the maximum depth of the die cavity 340, as shown in Figure 12. With the upper punch 272, upper platen 264 and its stop caps 276 in their raised positions of Figure 12, constituting their starting positions, the modified powdered material compacting assembly 230 is then ready to execute another cycle of operation, commencing with the advancement of the filling shoe 66 over the die cavity 340 to fill the latter with loose powdered material P, as before.

During operation of either of the forms of the invention shown in Figures 1 and 12 respectively, the previously-mentioned spring-centered four-way valve (not shown) which controls the admission and discharge of fluid to and from the opposite ends of the cushioning cylinders is shifted to mid-position to block both such admission and discharge so as to hold the die table stationary against the frictional drag of the upper punch or punches against the side walls of the die cavity and core rod during retraction of the upper punch or punches and subsequent ejection of the workpiece from the die cavity. These cushioning cylinders and their associated hydraulic circuits are the only hydraulic equipment used in conjunction with either of the forms of the present invention of Figures 1 and 12 respectively.

It will be understood that to provide variable speeds for the various electric motors 74, 116, 192 and 190 (Figures 1 and 2) direct current motors are most conveniently used even though it ordinarily necessitates the additional provision of a direct current dynamo driven by an alternating current motor from the alternating current supply most frequently found in industrial establishments. Such variable speeds increase the versatility of the press because of the fact that in high fills or complicated workpieces, the moving parts of the press must be slowed down so that the powdered material will flow properly into the various parts of the die cavity. Moreover, by the provision of the various clutches, shown as magnetic clutches but optionally employing other forms of clutches, the maximum power can be obtained from a single motor where otherwise separate reversible individual motors would have to be used, each of maximum power capacity. The reason for this lies in the fact that it is seldom necessary to propel any two of the screw plungers at a single time with full tonnage applied thereto. Ordinarily, in the majority of workpieces, the top of the workpiece receives the full tonnage of the press because it ordinarily constitutes the full area of the workpieces unless there are holes in the workpiece. For the same reason, the bottom of the workpiece where provided with flanges, ordinarily receives less applied tonnage because of the smaller individual areas involved.

Furthermore, in the modified form of the invention shown in Figure 12, the stationary piston rods 244 also serve as guide rods in addition to the guide rods 242. The internally screw-threaded stop sleeves 282 on the externally screw-threaded upward extensions 286 of the upper cylinder heads 288 mounted on the die table 260 when engaged by the stop shoulders 280 of the stop caps 276 on the upper platen 264 are depended upon to halt the descending motion of the upper platen relatively to the die table; but, in addition, just before these come into engagement, the yielding pressure within the cushioning cylinder 300 is automatically raised suddenly in order to provide an opposing resistance exceeding the force exerted by the descending die table 260 and upper platen 240. The arrangement is sufficiently accurate to provide accurate dimensions for the workpiece, and, when reversed, to provide sufficiently accurate ejection of the workpiece, because the minute amount of compression of the oil which constitutes the hydraulic working fluid is negligible. The stop arrangement provided by the externally-lobed disc 324 and the rotary internally-lobed sleeve 330 is made use of only when the nature of the workpiece does not require the cushioned or yielding descent of the die table 260, so that a fixed and immovable die table results.

WHAT I CLAIM IS:—

1. A powdered material briquetting press, comprising a press frame, a die table disposed intermediate the opposite ends of the press frame, and at least two lower and an upper punch support displaceably mounted on the press frame and adapted to support lower and upper punches, respectively, each punch support being provided with a screw thread which is engaged by an actuating mechanism to effect displacement of the punch support towards and away from the die table independently of displacement movement of any of the other punch supports.

2. A powdered material briquetting press according to claim 1, wherein at least the lower punch supports are tubular and wherein a core support is mounted within one of the lower punch supports, the core support being adapted to support a core element and being provided with a screw thread which is engaged by an additional actuating mechanism to effect displacement of the core support towards and away from the die table independently of the movement of any of the punch supports.

3. A powdered material briquetting press according to claim 1 or 2, comprising a plurality of telescoped lower and/or upper

punch supports each of which is provided with a screw thread which is engaged by an actuating mechanism to effect displacement of each punch support independently of any other support.

4. A powdered material briquetting press, according to any of claims 1 to 3, wherein each actuating mechanism comprises a forward and reverse power transmission device which includes two magnetic clutches selectively transmitting power, the one forwardly and the other reversely, to the respective punch support associated therewith.

5. A powdered material briquetting press, according to any of claims 1 to 4, wherein at least one actuating mechanism includes a rotary gear nut which threadedly engages the screw thread of the respective punch support.

6. A powdered material briquetting press according to claim 1, comprising lower outer, intermediate and inner tubular telescoping punch supports movable independently of one another and each adapted to support an individual independently movable tubular lower punch.

7. A powdered material briquetting press according to claim 6, wherein an independently movable core support is mounted within the inner punch support and is adapted to be connected to a core element, and wherein an independent motor-operated driving mechanism is drivingly connected to the core support.

8. A powdered material briquetting press according to claim 1, comprising upper outer and inner tubular telescoping punch supports movable independently of one another and each adapted to support an individual independently-movable tubular upper punch.

9. A powdered material briquetting press according to claim 1, wherein lower and upper platens are associated with the lower and upper punch supports, wherein elongated platen guide members are mounted in laterally-spaced parallel relationship within the press frame in guiding engagement with the platens, and wherein means are provided for detachably and removably securing the opposite ends of the guide members to the press frame.

10. A powdered material briquetting press according to claim 9, wherein the press frame includes a pair of frame side structures disposed in laterally-spaced relationship and having longitudinally-spaced pairs of projections thereon with the projections of each pair extending laterally inward toward and in alignment with one another, and wherein the opposite ends of the guide members are detachable and removably secured to the said projections.

11. A powdered material briquetting press according to any of the preceding claims, wherein the die table is movably mounted on the press frame for travel relatively thereto, and wherein stop devices are provided which are selectively engageable with an disengageable from the die table for selectively permiting travel thereof beyond and halting travel thereof at a predetermined location in the press frame.

12. A powdered material briquetting press according to claim 11, wherein the stop devices include pairs of stop elements with laterally-projecting lobes therein, one stop element of each pair being connected to the die table for travel therewith and the other element of each pair being rotatably mounted at a predetermined location on the press frame for rotation of its lobes selectively into and out of registry with the lobes of the stop elements connected to the die table.

13. A powdered material briquetting press according to claim 1, wherein elongated platen guide members are mounted on the press frame in laterally-spaced parallel relationship, wherein an upper platen is associated with the upper punch supports for actuation thereby in guided engagement with the guide members, wherein the die table has an extensible and retractable stop therein, and wherein the upper platen has a stop abutment therein engageable with the die table stop at a predetermined distance of separation of the upper platen from the die table.

14. A powdered material briquetting press, substantially as herein described and illustrated.

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17 Wilson Street,
London, E.C.2.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1970.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
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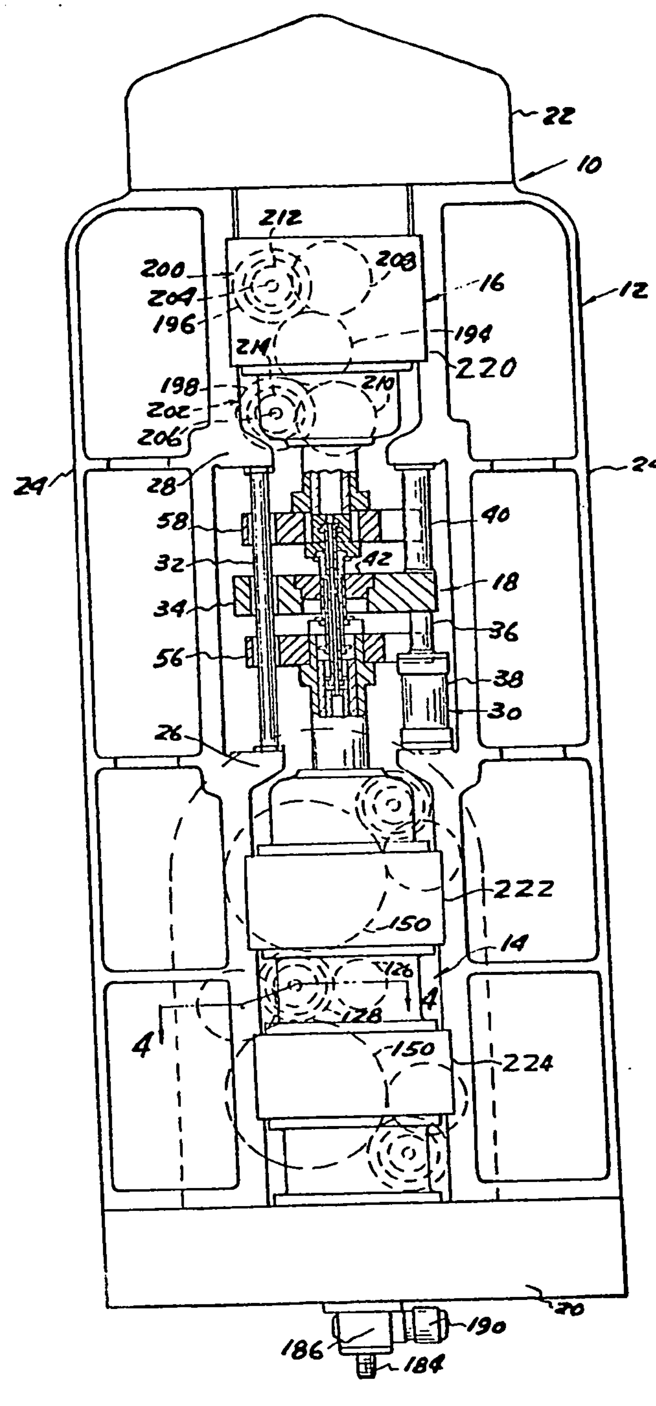
Sheet 1

FIG. I



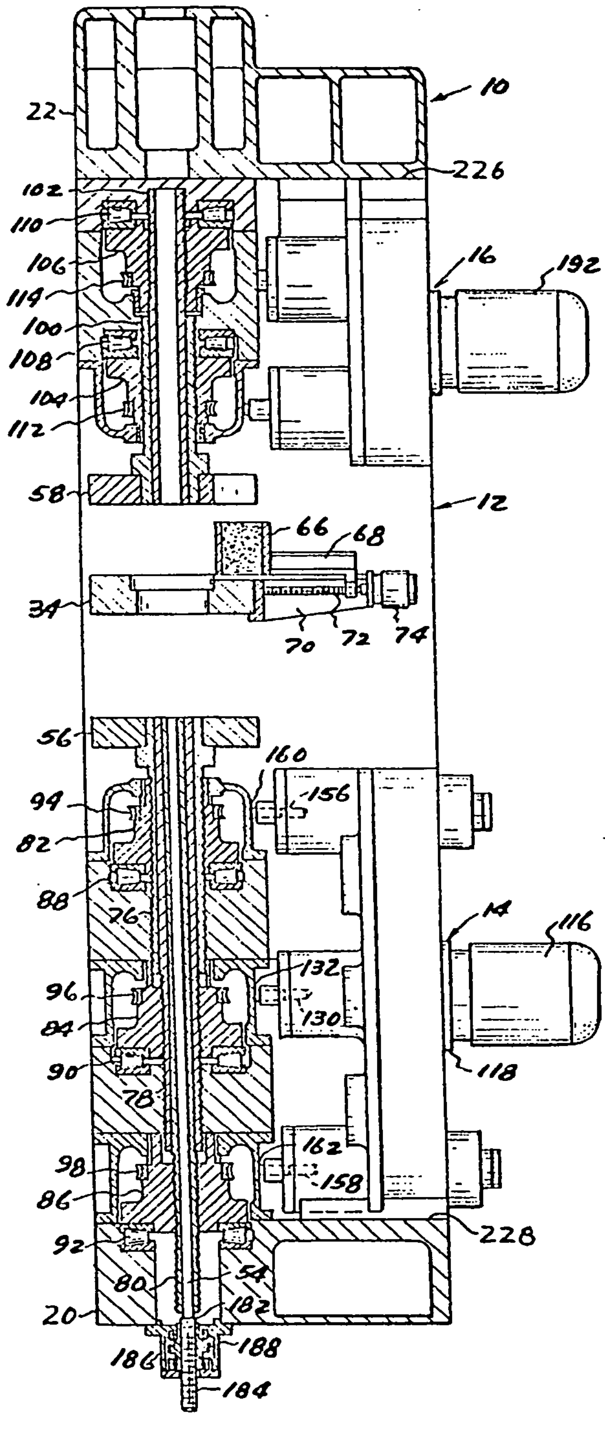

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FIG. 2

FIG. 3

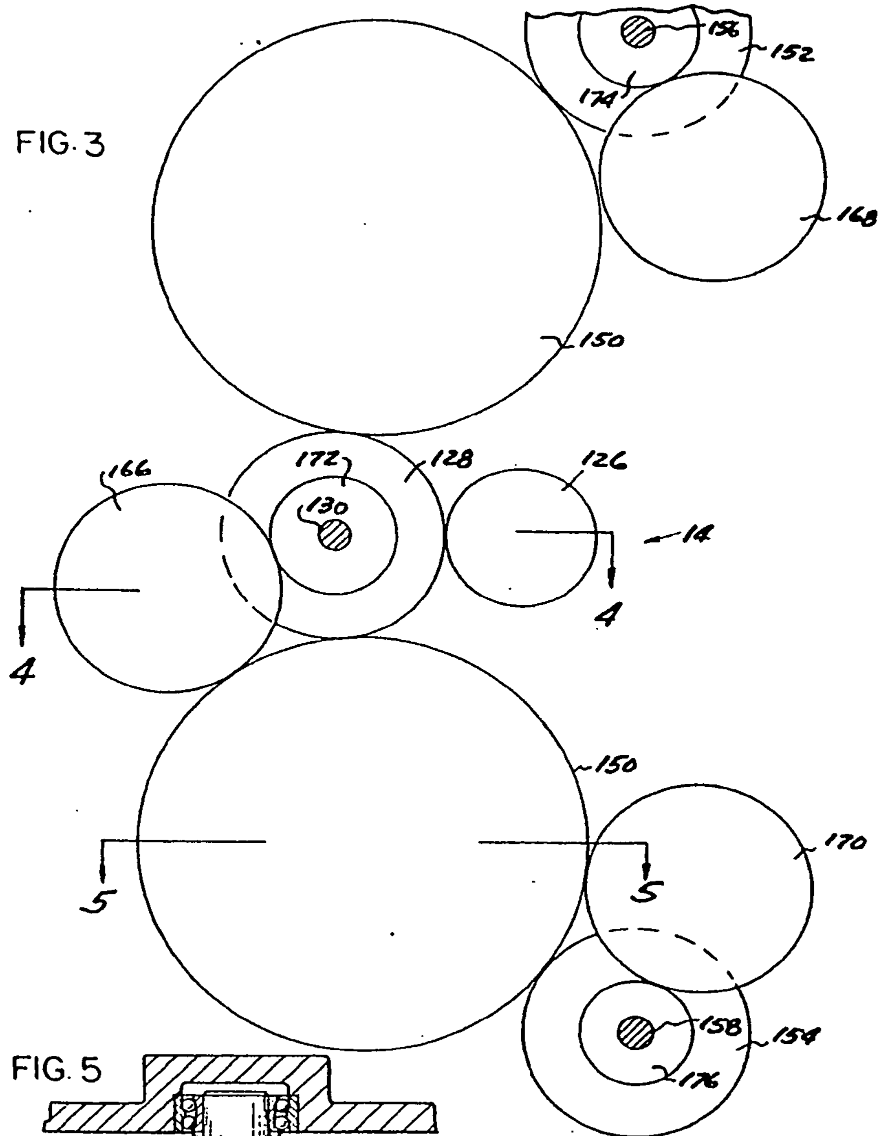
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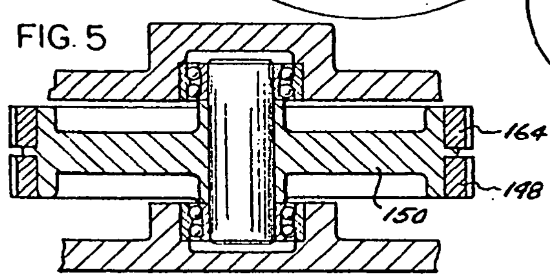
FIG. 5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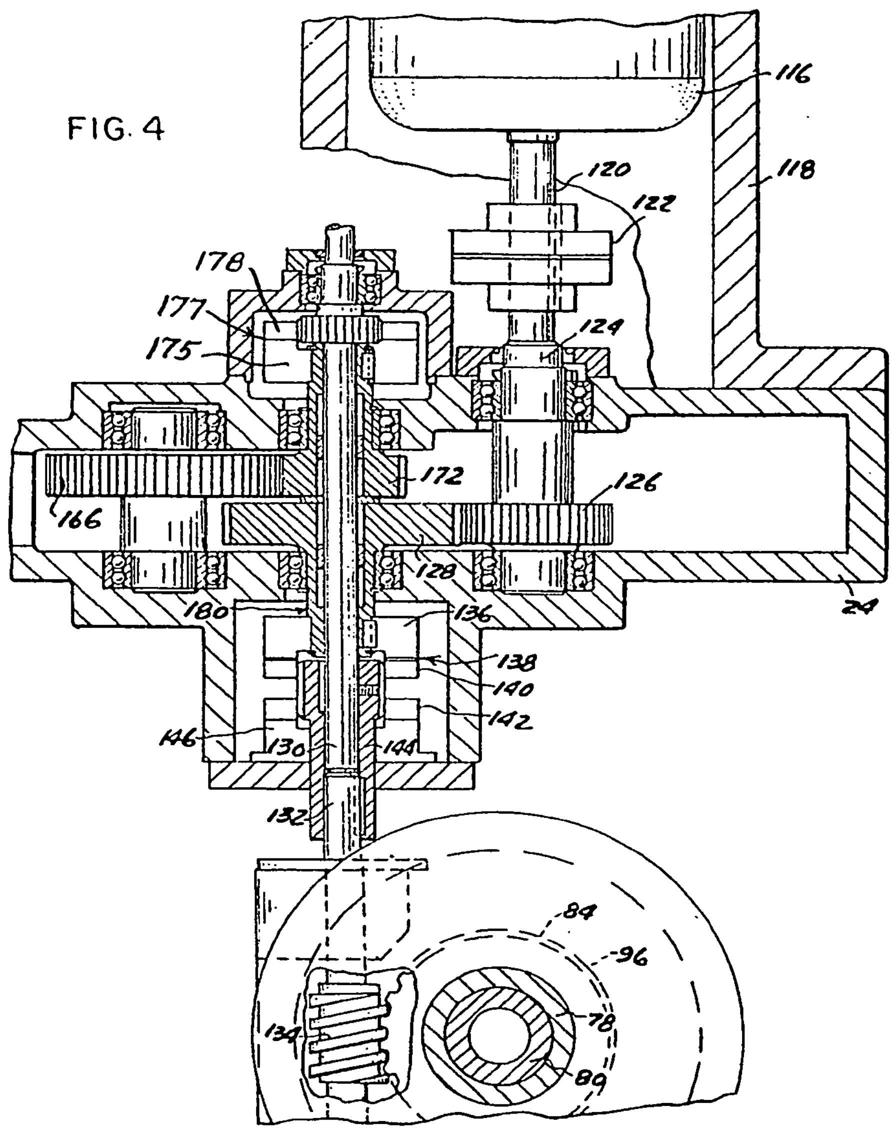
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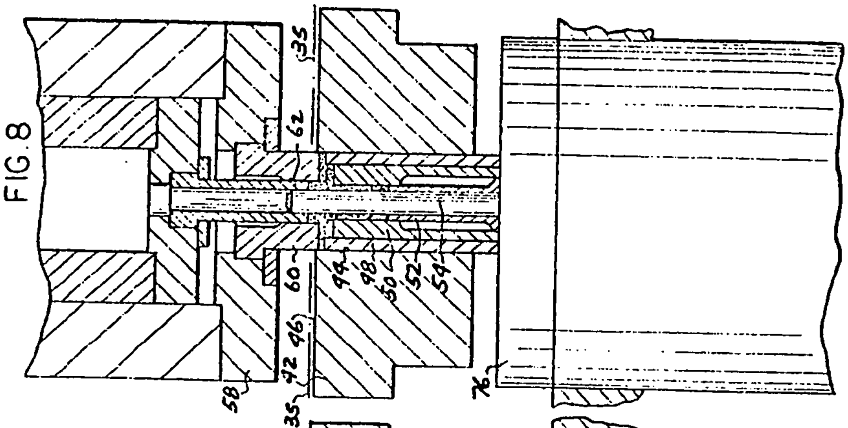
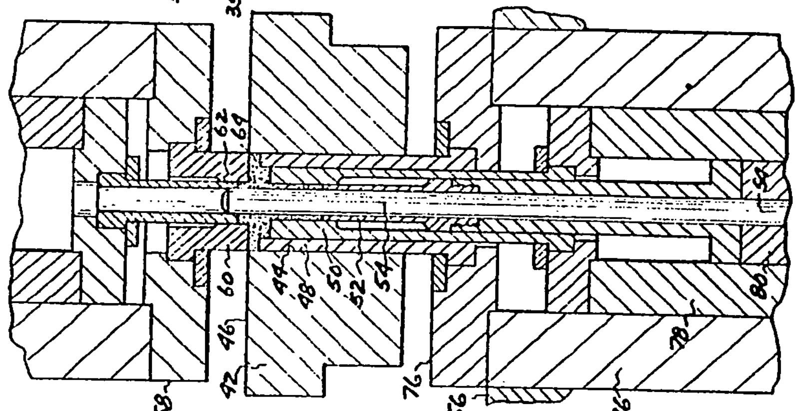


FIG.8



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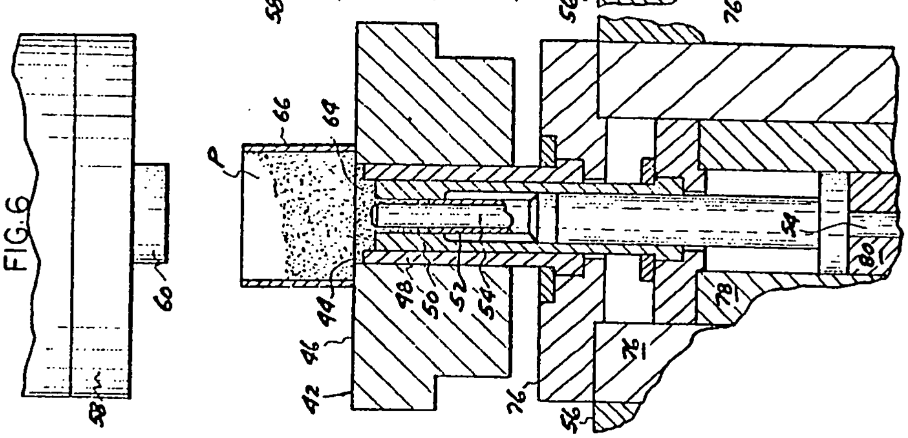

FIG.6

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Sheet 6

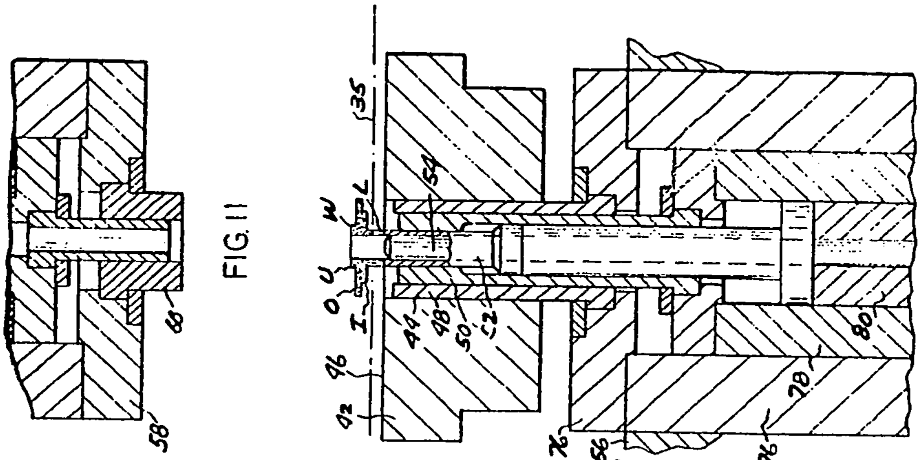
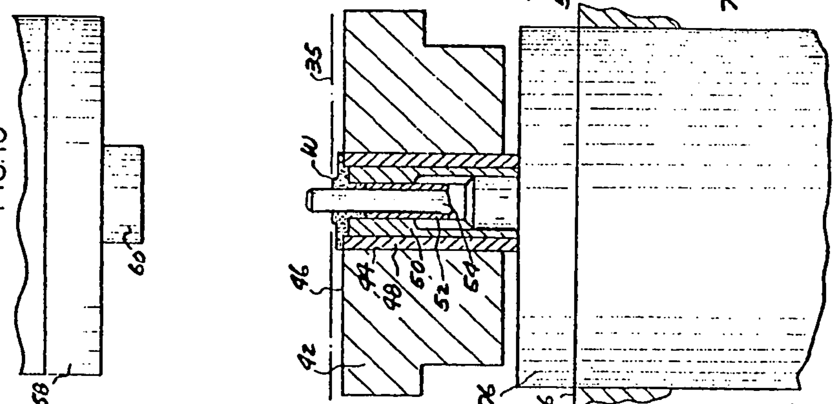


FIG. 11



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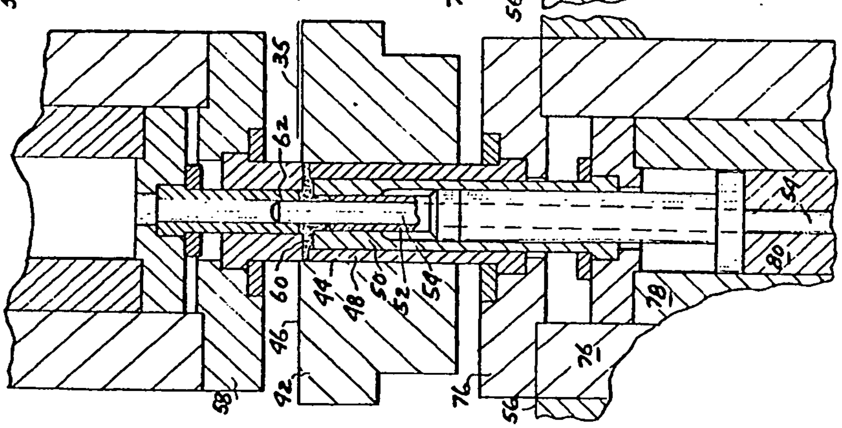
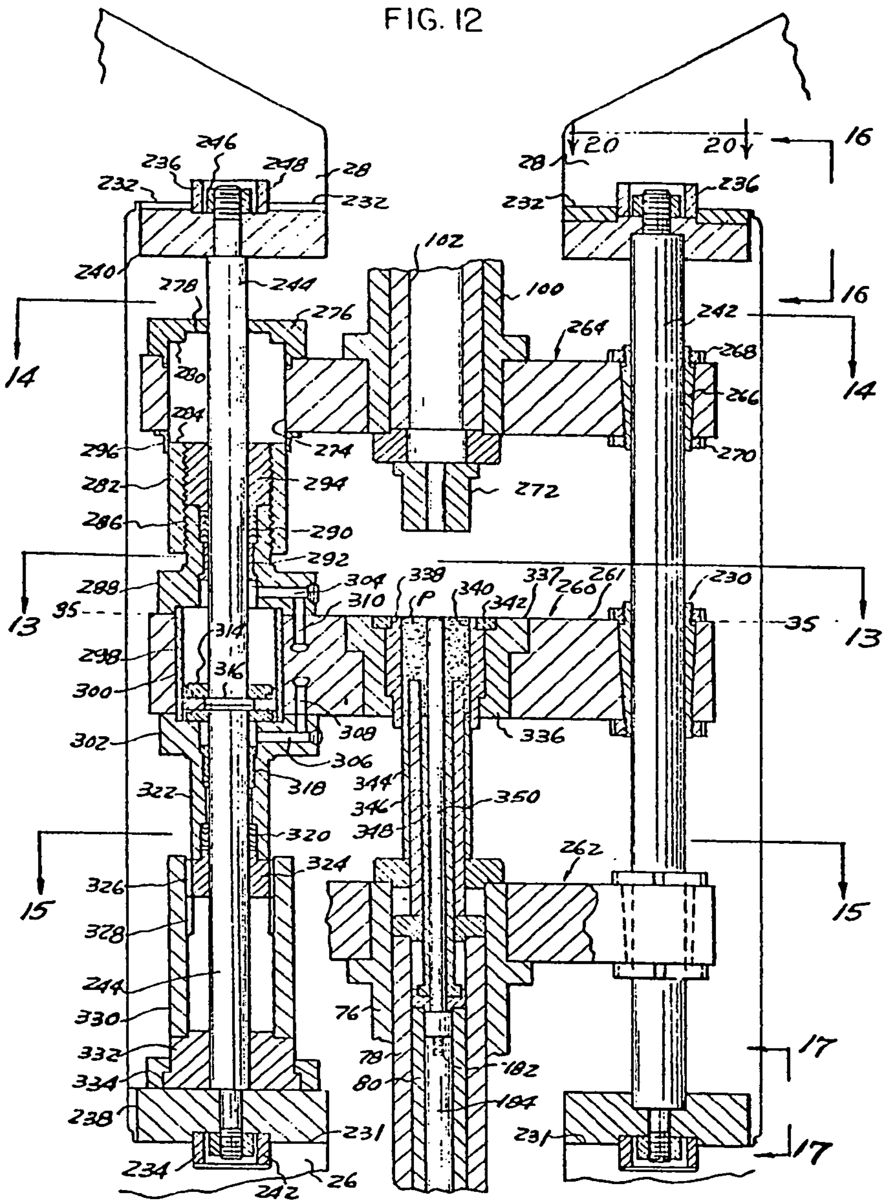


FIG. 9

FIG. 12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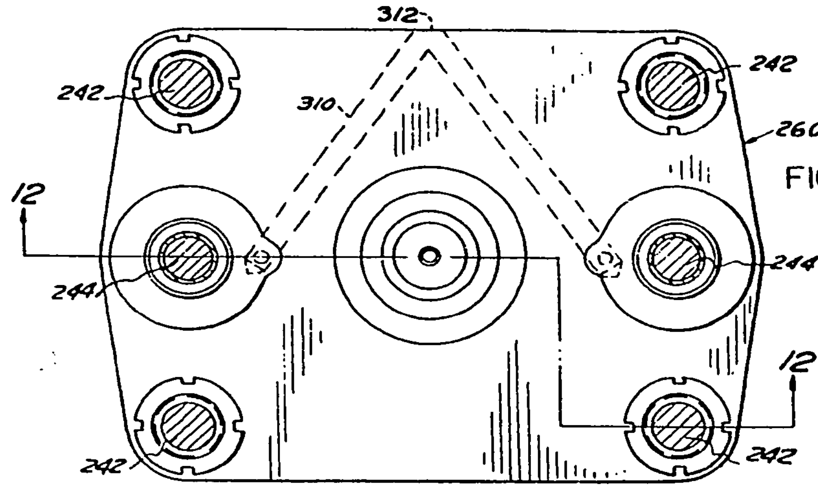


FIG. 13

FIG. 19

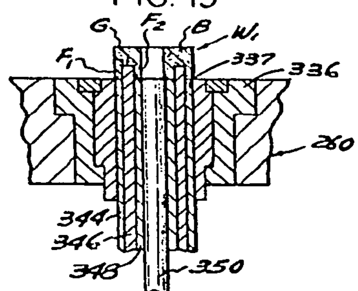


FIG. 18

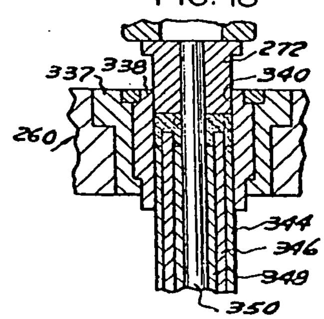


FIG. 16

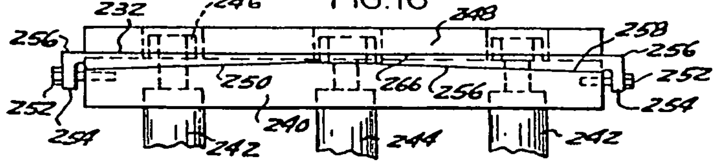
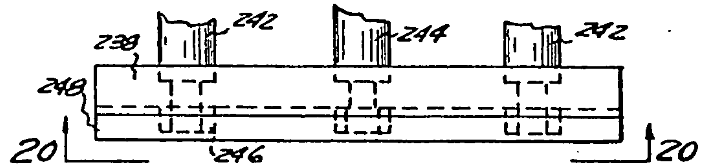


FIG. 17



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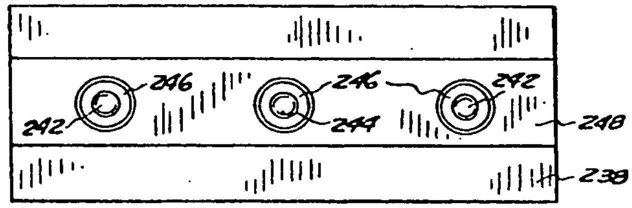
Sheet 9

FIG. 20



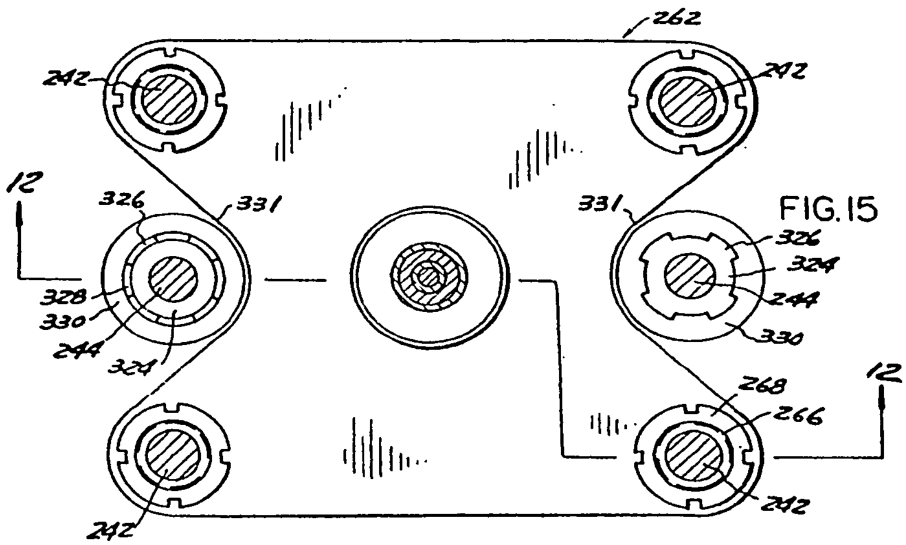


FIG. 15

FIG. 14